

NEW SPECIES OF PARASITIC NEMATODES FROM MACROPODID MARSUPIALS IN WESTERN AUSTRALIA

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Summary

APPAN, A., BERGFELD, J. & BEVERIDGE, I. (2004) New species of parasitic nematodes from macropodid marsupials in Western Australia. *Trans. R. Soc. S. Aust.* 128(2), 77-84, 30 November, 2004.

Two new species of parasitic nematodes are described from macropodid marsupials from Western Australia. *Rugopharynx setonicis* sp. nov. from the stomach of the quokka, *Setonix brachyurus*, belongs to the *Rugopharynx australis* complex, but differs from related species in the anterior position of the nerve ring, a shorter spicule length and the anterior position of the deirids. A second new species, from the oesophagus of *Macropus irma*, is described. *Cyclostrongylus irma* sp. nov. is distinguished from congeners by a buccal capsule which is wider near its anterior extremity, longer spicules and a short oesophagus. The descriptions of the two new species provide additional evidence in support of eurrent hypotheses for the mode of evolution of the respective genera.

KEY WORDS : Nematoda, marsupials, *Macropus*, *Setonix*, new species, *Rugopharynx*, *Cyclostrongylus*.

Introduction

Kangaroos and wallabies harbour an extremely diverse fauna of helminth parasites (Spratt *et al.* 1991), dominated numerically by species of the strongyloid subfamily Cloacininae Stossich, 1889 which occur principally in the stomachs and to a lesser extent the oesophagi of these hosts (Beveridge & Spratt 1996; Beveridge & Chilton 2001). In spite of the fact that some 36 genera and 256 species have been described thus far within the subfamily (Beveridge & Chilton 2001), substantial numbers of species remain undescribed (Spratt *et al.* 1991; Beveridge & Chilton 2001). Apart from their numerical importance and possible role in disease (Beveridge & Presidente 1978), the nematodes are also of interest due to the fact that some genera inhabit unusual sites within the gastrointestinal tract such as the oesophagus (e.g. *Cyclostrongylus* Johnston & Mawson, 1939) and in some genera, large numbers of cryptic species are present (e.g. *Rugopharynx* Mönnig, 1927), suggesting recent and rapid evolutionary expansions within the parasite genus (Beveridge & Chilton 1999, 2001). In addition, recent phylogenetic studies (Beveridge & Chilton 2001) indicate that colonization has been the major mode of diversification rather than cospeciation. Thus the nematode parasites of macropodids are of particular biological as well as of taxonomic interest.

The nematode parasites of eastern Australian macropodid species have been studied to a much greater degree than those of western Australia (see summary in Beveridge & Chilton 2001), such that

much descriptive work remains to be carried out in hosts from the latter region. In this paper, two new species of nematodes are described from Western Australian marsupials, a new species from the *Rugopharynx australis* (Mönnig, 1926) species complex, which has apparently undergone a recent and dramatic evolutionary expansion in macropodids (Beveridge & Chilton 2001) and a new species of the genus *Cyclostrongylus*, a genus which is highly unusual in occurring coiled around papillae in the oesophagus of its host.

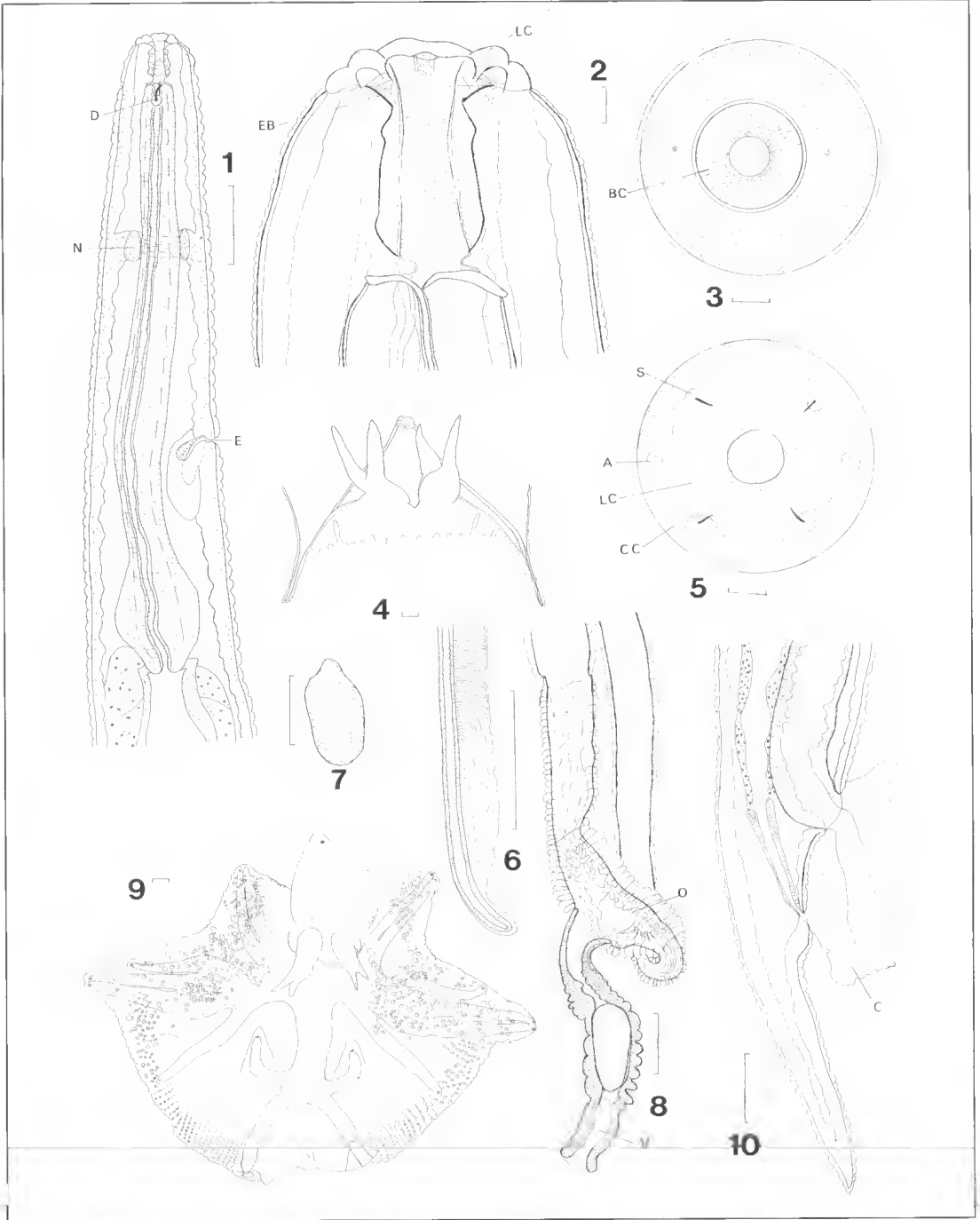
Materials and Methods

Nematodes were collected from macropodids obtained as road-kills. Host animals, which had been frozen following collection, were thawed and stomach or oesophageal content containing nematodes was fixed in 10% formalin for transportation to the laboratory. In the laboratory, nematodes were extracted from fixed stomach content, washed in water to remove formalin and stored in 70% ethanol.

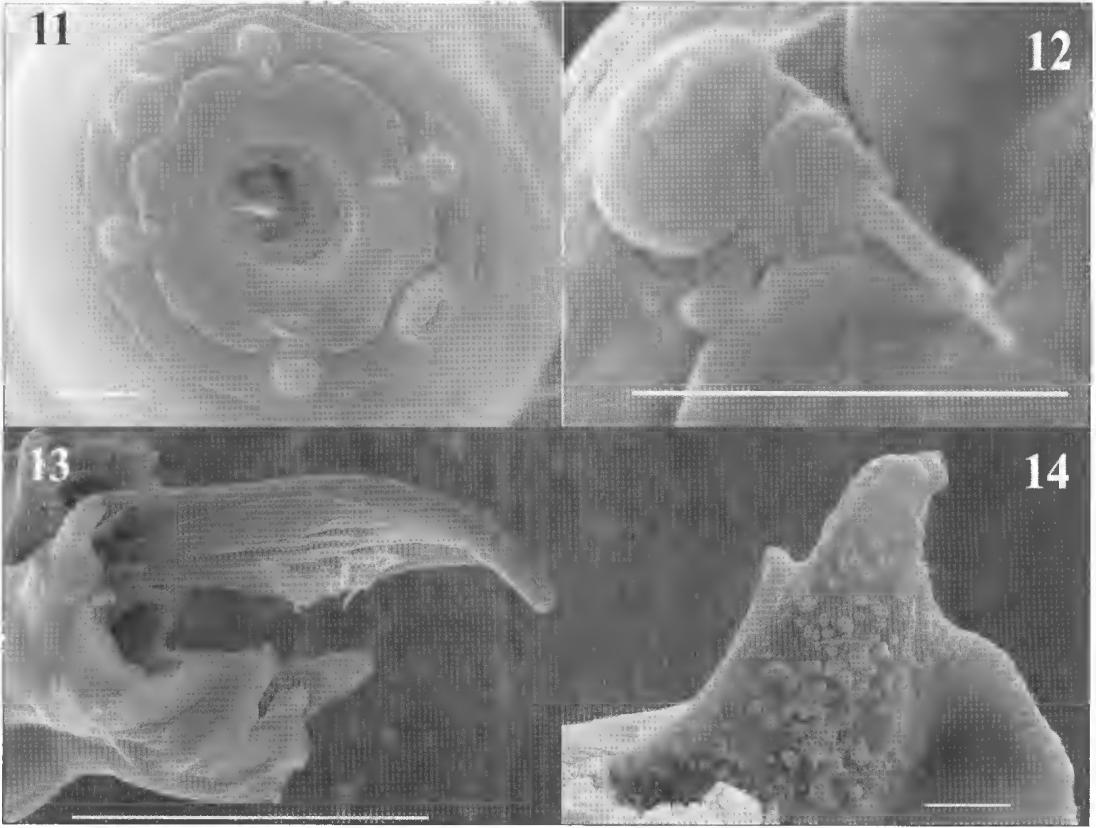
All specimens were examined after clearing in lactophenol. Drawings were made with the aid of a drawing tube attached to an Olympus BH2 microscope. Apical views of the anterior end and body sections are oriented with the dorsal aspect uppermost; extended bursae are oriented with the ventral lobes uppermost. Measurements were made with an ocular micrometer and are presented in mm as the range followed by the mean in parentheses. Morphological terminology follows Beveridge & Chilton (1999) for the description of the new species of *Rugopharynx* and Beveridge (1982) for the description of the new species of *Cyclostrongylus*.

Types of new species have been deposited in the

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Figs 1-10. *Rugopharynx setonicis* sp. nov. from the stomach of *Setonix brachyuris*. 1. Anterior end, lateral view. 2. Buccal capsule, lateral view. 3. Transverse optical section through buccal capsule. 4. Genital cone dorsal view. 5. Apical view of cephalic extremity. 6. Spicule tip, lateral view. 7. Gubernaculum, ventral view. 8. Terminal female genitalia, lateral view. 9. Bursa, apical view. 10. Female tail, lateral view. Scale bars = 0.1 mm, 1, 8, 10; 0.01 mm, 2-7, 9. Legend: A, amphid; BC, buccal capsule; C, cementum; CC, cephalic collar; D, deirid; E, excretory pore; EB, extrabuccal support; LC, labial collar; N, nerve ring; O, ovejector; S, submedian papilla; V, vagina.



Figs 11-14. Scanning electron micrographs of *Rugopharynx setonicis* sp. nov. from the stomach of *Setonix brachyurus*. 11. Apical view of anterior end showing collars and stoma. 12. Submedian cephalic papilla armed with seta with bifurcate extremity. 13. Bursa with everted spicule tips. 14. Bosses on internal surface of lateral lobe of bursa. Scale bars = 0.1 mm, 11-13, 0.01 mm, 14.

collections of the South Australian Museum, Adelaide (SAM), the Natural History Museum, London (BMNH) and the United States National Parasite Collection (USNPC).

Several specimens of each species were examined by scanning electron microscopy (SEM). Specimens were dehydrated in an ethanol series, transferred to hexamethyldisilane, allowed to dry, then sputter-coated with gold and examined with a Phillips 505 SEM using an accelerating voltage of 5-10KV.

Results

Rugopharynx setonicis sp. nov. (FIGS 1-14)

Types

Holotype ♂ from stomach of *Setonix brachyurus* (Quoy & Gaimard, 1830), Wellington Dam, Western Australia (33° 24' S 116° 00' E), coll. R. Brazelle, SAM 32182. Allotype ♀, same data, SAM 32183.

Paratypes: 5 ♂, 5 ♀, same data, SAM 32184; 1 ♂, 1 ♀, BMNH 2003.2.7.1-2; 1 ♂, 1 ♀, USNPC 93586.

Description

Chabertiidae (Popova, 1952); Cloacinae Stossich, 1899. Small worms; body covered with numerous fine transverse annulations. Prominent cephalic collar present (Fig. 2). Collar with paired lateral amphids on prominent elevations, and 4 conical, sub-median papillae; each papilla bearing single, medially-directed seta; setae only visible in apical preparations of head (Fig. 5); scanning electron micrographs (Fig. 12) show seta arising from bulbous expansion on medial aspect of papilla; seta bifid distally with one branch much shorter than other. Prominent, continuous labial collar internal to cephalic collar (Figs. 5, 11), collar indented medial to amphids and sub-median papillae. Stoma circular in apical views of head; labial collar continuous internally with lining of buccal capsule. Prominent extra-buccal supports present surrounding anterior extremity of buccal

capsule (Fig. 2). Buccal capsule short, thick-walled, variable in shape, longer than wide, thicker at anterior extremity with slight constriction at one sixth of length. Buccal capsule with numerous transverse striations; striations sinuous, faint, branch and anastomose frequently; near anterior extremity, striations faint and irregular; in optical transverse section, striae radially arranged (Fig. 3). Oesophageal corpus elongate, sub-cylindrical, slightly wider towards posterior extremity (Fig. 1); isthmus short, leading to elongate, clavate bulb. Deirids in anterior oesophageal region. Nerve ring encircles oesophageal corpus at $\frac{1}{3}$ length, anterior to isthmus. Excretory pore between nerve ring and isthmus (Fig. 1).

Male

Measurements of 10 specimens, types. Total length 5.30 – 6.48 (6.15); maximum width 0.28 – 0.35 (0.30); buccal capsule 0.030 – 0.040 (0.037) long by 0.015 (0.015) wide; oesophagus 0.70 – 0.85 (0.79) long; nerve ring to anterior end 0.34 – 0.40 (0.38); excretory pore to anterior end 0.40 – 0.50 (0.48); deirids to anterior end 0.09 – 0.13 (0.11). Bursa short; dorsal lobe with slight indentation in margin; dorsal lobe equal in length to lateral lobes; lateral lobes with erenulate margins with radially directed striae close to margin. Internal surfaces of ventral and lateral lobes with numerous refractile bosses; bosses overlie ventral and lateral rays, extend in marginal band along lateral lobes between postero-lateral and externo-dorsal rays (Fig. 9). Ventro-ventral and latero-ventral rays slender, apposed, reaching margin of bursa. Medio-lateral and postero-lateral rays stout, reaching margin of bursa; externo-lateral ray shorter, divergent, originates close to base of lateral trunk, slightly reflexed near distal extremity, terminating in elevation of cuticle close to margin of bursa. Externo-dorsal ray originates close to lateral trunk, stout, straight, almost reaches margin of bursa. Dorsal ray broad at origin, divides at mid-length; internal branchlets arcuate, elongate, directed posteriorly, reach margin of bursa; external branchlets arise at main bifurcation, slightly shorter than internals, recurrent, terminate in elevations of cuticle on internal surface of bursa. Genital cone prominent; anterior lip large, conical; posterior lip with pair of bilobed appendages and ring of smaller projections around base (Fig. 4). Spicules 1.00 – 1.34 (1.20) long, alate; proximal tips knobbed, shafts cylindrical, distal tips blunt with slight terminal enlargement; alae broad, diminish in width towards tip, lose striations (Fig. 6). Gubernaculum poorly sclerotised, visible in lateral views but rarely visible in dorso-ventral views (Fig. 7); cordate and paired lateral thickenings of spicule sheaths present.

Female

Measurements of 10 specimens, types. Total length

6.75 – 7.90 (7.36); maximum width 0.28 – 0.36 (0.32); buccal capsule 0.03 – 0.05 (0.04) long by 0.015 (0.015) wide; oesophagus 0.83 – 0.96 (0.89) long; nerve ring to anterior end 0.37 – 0.42 (0.39); excretory pore to anterior end 0.43 – 0.57 (0.48); deirids to anterior end 0.09 – 0.11 (0.10); tail elongate, tapering, 0.35 – 0.50 (0.44) long; vulva 0.50 – 0.62 (0.58) from posterior end, frequently surrounded by mass of cementum (Fig. 10); vagina straight, short, 0.34 – 0.55 (0.43) long; ovejector J-shaped; vestibule longitudinally disposed, differentiation between sphincters and infundibula indistinct (Fig. 8); egg ellipsoidal 0.11 – 0.14 (0.12) long by 0.05 – 0.06 (0.055) wide.

Cyclostrongylus irma sp. nov. (FIGS 15-28)

Synonyms

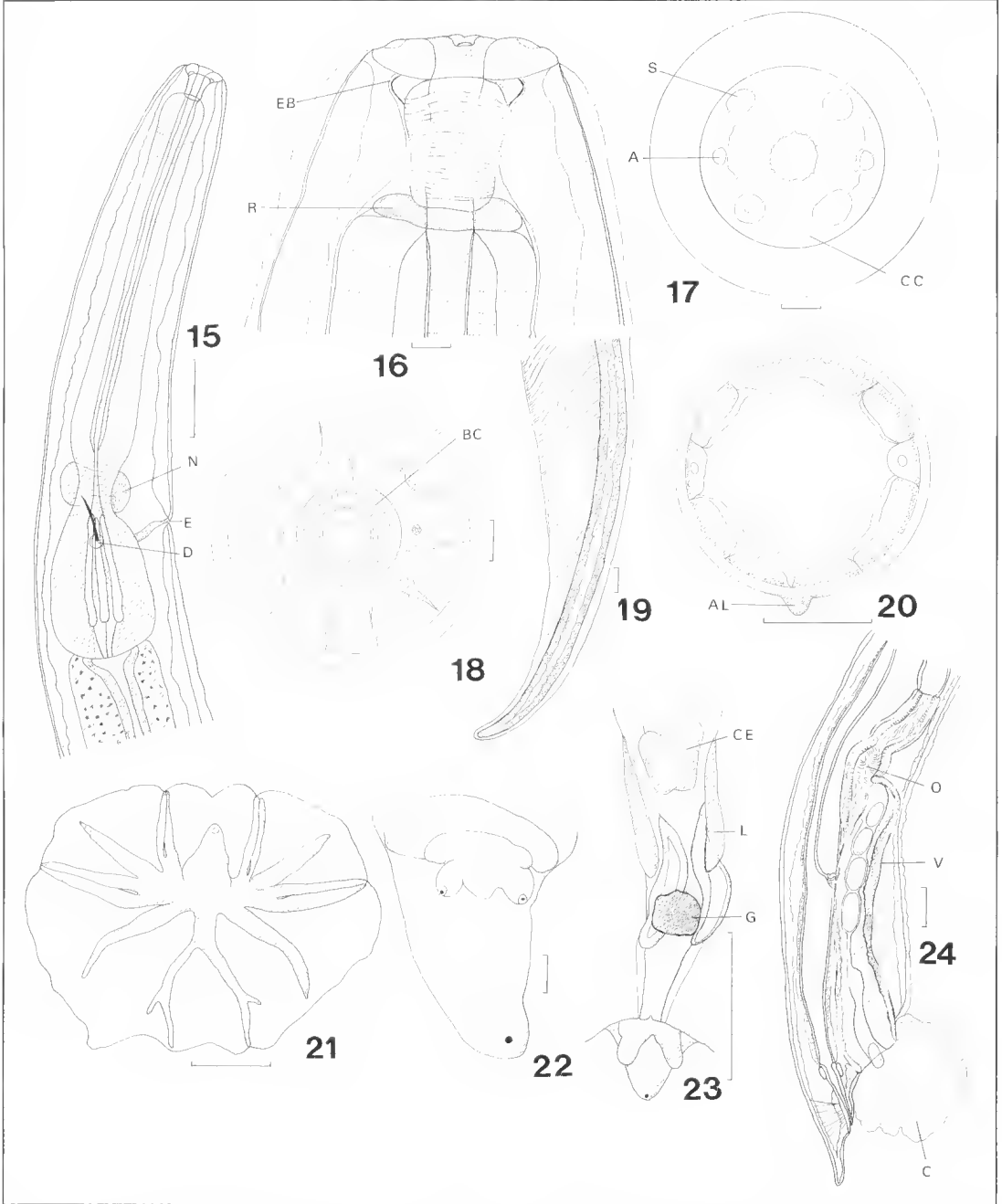
Cyclostrongylus wallabiae Johnston & Mawson, 1939 of Spratt *et al.* 1991, p. 51.

Types

Holotype ♂ from oesophagus of *Macropus irma* (Jourdan, 1837), Collie, Western Australia (33° 22' S 116° 09' E), 11.xii.2001, coll. R. Brazelle, SAM 32185. Allotype ♀, same data, SAM 32186. Paratypes: 10♂, 20♀, same data, SAM 32187; 1♂, 1♀, BMNH 2003.2.7.3-4; 1♂, 1♀, USNPC 93587. *Other material examined*: from oesophagus of *M. irma*: Western Australia: 14♂, 14♀, Perth, Feb. 1981, coll. P. Christensen (SAM 8324); 23♂, 22♀, Jandakot, April, 1982, coll. L. Jue Sue (SAM 11545).

Description

Chabertiidae (Popova, 1952); Cloaciniinae Stossich, 1899. Small nematodes up to 12mm long. Mid-region of bodies coiled around oesophageal papillae of host; males usually with a single coil (Fig. 25), female nematodes with 2 or more coils (Fig. 26). Body covered with numerous transverse annulations. Single triangular ala present on the ventral surface (Figs. 20, 27), extending along mid-body region. Cephalic collar distinct, with 2 slightly domed amphids and 4 domed submedian papillae. No labial crown or collar. Mouth opening and buccal capsule circular in apical view (Fig. 17) and optical cross-section respectively (Fig. 18). Buccal capsule short, thick-walled, transversely striated; all of buccal capsule thicker anteriorly; transverse striations regular, extend along entire buccal capsule (Fig. 16). Extra-buccal supports prominent. Prominent, refractile ring present between buccal capsule and oesophagus. Oesophagus short, corpus widening slightly before constriction at isthmus; ovoid oesophageal bulb with 3 sclerotised plates (Fig. 15). Excretory pore at level of deirids, latter at



Figs 15-24. *Cyclostrongylus irma* sp. nov. from the oesophagus of *Macropus irma*. 15. Anterior end, lateral view. 16. Cephalic end, lateral view. 17. Cephalic end, apical view. 18. Transverse optical section through buccal capsule. 19. Distal tip of spicule, lateral view. 20. Transverse section through mid-region of body showing ventral ala. 21. Bursa of male, apical view. 22. Genital cone, dorsal view. 23. Gubernaculum and thickenings of spicule sheath, ventral view. 24. Posterior end of female, lateral view. Scale bars = 0.1 mm, 15, 21, 23, 24, 0.01 mm, 16-20, 22. Legend: A, amphid; AL, ala; BC, buccal capsule; C, cementum; CE, central cordate thickening of spicule sheath; CC, cephalic collar; D, deirid; E, excretory pore; EB, extrabuccal support; G, gubernaculum; L, lateral thickening of spicule sheath; N, nerve ring; O, ovejector; R, post-buccal sclerotised ring; S, submedian papilla; V, vagina.

level of mid-oesophageal bulb. Nerve ring encircles oesophageal isthmus.

Male

Measurements of 10 specimens, types. Total length 8.78 – 9.84 (9.60); maximum width 0.22 – 0.28 (0.24); buccal capsule 0.035 – 0.045 (0.042) long by 0.030 (0.030) wide; oesophagus 0.65 – 0.75 (0.71) long; nerve ring 0.49 – 0.56 (0.52) from anterior end; excretory pore 0.57 – 0.69 (0.62) from anterior end; deirid 0.59 – 0.72 (0.66) from anterior end. Bursa short, lobes of equal size (Fig. 21). Separation of lobes indistinct; no striae or bosses on internal surface of bursa. Ventro-ventral and ventro-lateral rays slender, apposed, reaching margin of bursa. Lateral rays stout; medio-lateral and postero-lateral rays apposed, reaching margin of bursa; externo-lateral ray divergent, joins lateral trunk near origin, does not reach margin of bursa. Externo-dorsal ray originates close to lateral trunk, not reaching margin of bursa, curves slightly near tip. Dorsal ray bifurcates $\frac{1}{4}$ -length, each major branch with small laterally-directed branch arising more than half-way along its length; 2 major branches of the dorsal ray reaching margin of bursa. Spicules alate, 1.25 – 1.48 (1.38) long; proximal extremity knobbed; shaft cylindrical; distal tip blunt, slightly recurved (Fig. 19); ala diminishes in width towards tip, loses transverse striations. Gubernaculum approximately quadrangular in dorsoventral view (Fig. 23), 0.10 – 0.20 (0.14) long. Genital cone prominent; anterior lip large, conical; posterior lip with 2 lobe-like appendages (Fig. 22). Central cordate and lateral paired thickenings of spicule sheaths present (Fig. 23).

Female

Measurements of 10 specimens, types. Total length 9.55 – 11.58 (10.81); maximum width 0.30 – 0.34 (0.32); buccal capsule 0.040 – 0.050 (0.045) long by 0.030 – 0.040 (0.034) wide; oesophagus 0.73 – 0.84 (0.79) long; nerve ring 0.52 – 0.57 (0.55) from anterior end; excretory pore 0.61 – 0.70 (0.65) from anterior end; deirid 0.63 – 0.71 (0.68) from anterior end. Tail short, conical, 0.14 – 0.18 (0.16) long; vulva immediately anterior to anus, 0.23 – 0.36 (0.29) from posterior end, frequently surrounded by mass of cementum (Fig. 24); vagina straight, 0.08 – 0.22 (0.14) long; ovejector longitudinally disposed. Egg thin shelled, ovoid, 0.06 – 0.09 (0.08) long by 0.04 – 0.05 (0.05) wide.

Discussion

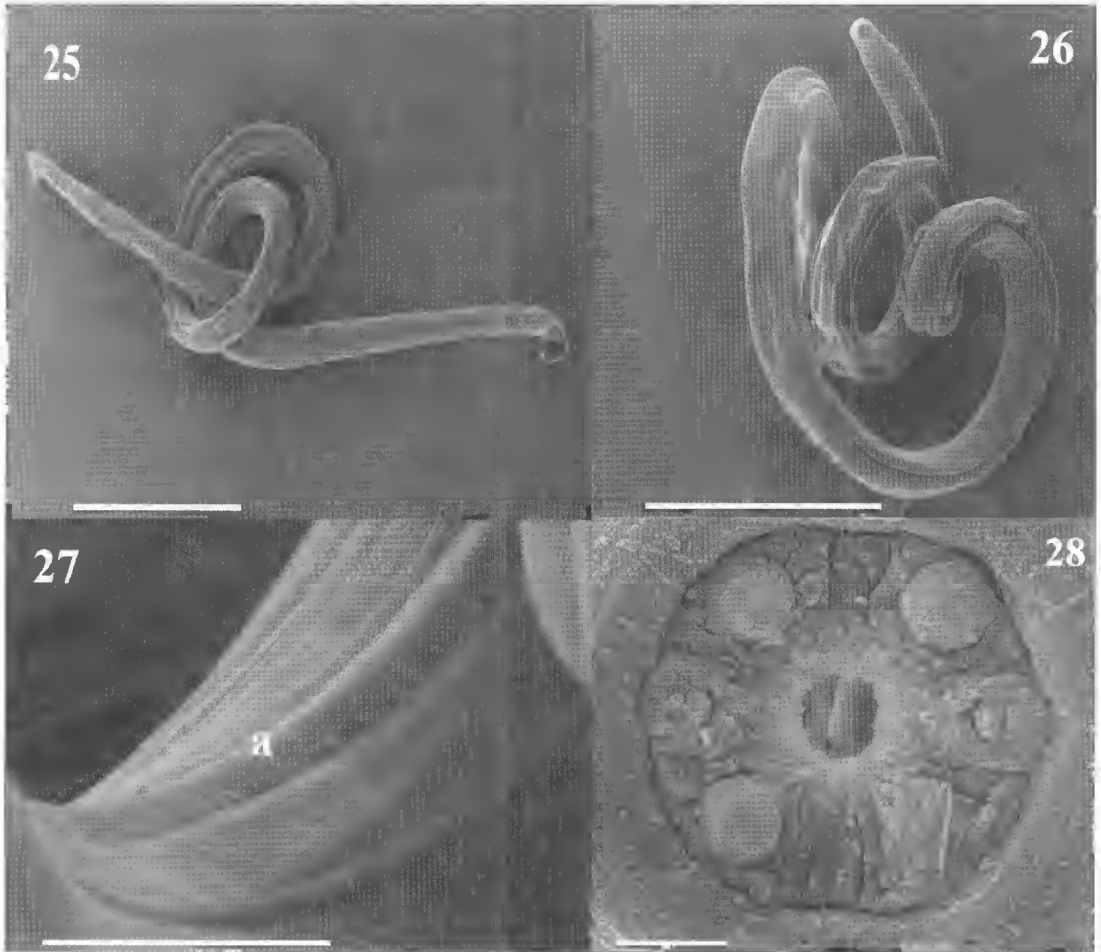
The specimens described from the stomach of *Setonix brachyurus* are allocated to the genus *Rugopharynx*, due to the presence of two pairs of

branches to the dorsal ray, a cylindrical buccal capsule and the externo-dorsal ray arising with the lateral rays, all characters of the subfamily Cloacininae. The prominent transverse striations of its buccal capsule, short oesophageal corpus and lack of petaloid or lobed labial crown elements and alae place it in the genus *Rugopharynx*. Within the genus, the sub-cylindrical buccal capsule, lacking prominent subdivisions, places it within the *Rugopharynx australis* complex (Beveridge 1982; Beveridge & Chilton 1999).

Within this complex, the specimens cannot be attributed to any of the known species (Beveridge & Chilton 1999). The nerve ring encircles the anterior part of the oesophageal corpus rather than the isthmus, hence differentiating them from all species except *R. petrogale* Beveridge & Chilton, 1999, *R. rosemariae* Beveridge & Presidente, 1978 and *R. rho* Beveridge & Chilton, 1999. The specimens described here lack the small sclerotised bosses lining the oesophagus which are characteristic of *R. rosemariae* and the length of the spicules, 1.00 – 1.34 (1.20) mm, is significantly shorter than those of *R. rosemariae* (3.85 – 4.35 mm). *R. rho* has a non-lobed buccal capsule but its spicules (1.65 – 1.92 mm) are significantly longer. *R. petrogale* has three, very weakly-developed lobes to the wall of the buccal capsule, compared with the current specimens which have the buccal capsule wall slightly thickened at its anterior extremity. In addition, the dorsal ray in *R. petrogale* is longer than the lateral rays while in the specimens described here, the rays are of similar length. The proximity of the deirids to the anterior end of the nematode also differ significantly from specimens of *R. petrogale*. For these reasons, the material described is considered to represent a new species, and is named *R. setonicis* sp. nov. as the quokka, *Setonix brachyurus*, is its only known host.

Beveridge & Chilton (2001) examined the host range of members of the *R. australis* complex and concluded that the distribution of nematode species bore no relationship to the phylogeny of the hosts. They suggested that members of this species complex may have evolved recently, due to the relatively minor morphological differences between their constituent members, and that colonization of hosts had occurred rather than co-speciation. The addition of a new member of the complex from *Setonix* is consistent with this hypothesis given the relatively basal (though uncertain) position of *Setonix* in the phylogeny of the Macropodidae (Flannery 1989).

Two genera of cloacinid nematode are known to occur coiled around the oesophageal papillae of wallabies, namely *Cyclostrongylus* Johnston & Mawson, 1929 and *Spirostrongylus* Yorke &



Figs 25-28. *Cyclostrongylus irma* sp. nov. from the oesophagus of *Macropus irma*. 25. Male nematode. 26. Female nematode. 27. Internal (ventral) surface of body coil showing central ala (a). 28. Mouth opening, amphids and submedian papillae. Scale bars = 1.0 mm, 25, 26, 0.1 mm, 27, 0.01 mm, 28.

Maplestone, 1926 (see Beveridge 1982). *Spirostrongylus* possesses a lobed labial collar, while in *Cyclostrongylus*, a labial collar is totally lacking (Beveridge 1982). The specimens described here therefore belong to *Cyclostrongylus* and have previously been allocated to *C. wallabiae* (Johnston & Mawson, 1939) (see Spratt *et al.* 1991), a species which occurs commonly in the swamp wallaby, *Wallabia bicolor* (Desmarest, 1804).

The genus *Cyclostrongylus* currently comprises six species (Beveridge 1982). Morphologically, the species of *Cyclostrongylus* occurring in the oesophagus *M. irma* is most similar to *C. wallabiae* in possessing a buccal capsule which is wider in diameter towards the anterior end, rather than being perfectly cylindrical and in having regular transverse striations extending to the anterior extremity of the

buccal capsule. It was presumably for this reason that specimens of *Cyclostrongylus* from *M. irma* have hitherto been identified as *C. wallabiae* (see Spratt *et al.* 1991). However, the specimens described from *M. irma* differ in the length of spicules in the males (0.94 – 1.10 mm in *C. wallabiae*; 1.25 – 1.48 mm in specimens from *M. irma*). In addition, the bursa of *C. wallabiae* is greatly elongated dorsoventrally (Beveridge 1982, Fig. 324), while in the specimens from *M. irma*, the bursa is wider than long (Fig. 21). As a consequence of the difference in shape of the bursa, the stem of the dorsal ray is relatively much longer in *C. wallabiae* (see Beveridge 1982, Fig. 324) than in material from *M. irma*. The length of the oesophagus in specimens from *M. irma* is also shorter than those of *C. wallabiae* (0.65 – 0.75 mm in males and 0.73 –

0.84 mm. in females from *M. irma*, mean lengths 9.6 and 10.8 mm respectively; 0.85 – 0.97 mm in males and 0.87 – 1.02 mm in females of *C. wallabiae*, mean lengths 10.8 and 11.6 mm respectively).

The data presented here indicate that the specimens in *M. irma* are very similar but morphologically distinct from *C. wallabiae* and are therefore considered to represent a new species, herein named *C. irma* sp. nov.

The presence of the ventral ala in *C. irma* may assist the nematode in attaching to the papillae on the surface of the oesophagus of its host as has been suggested for other species (Beveridge 1982).

Beveridge & Chilton (2001) examined the relationships between species of the genus *Cyclostrongylus* and the phylogeny of their hosts. Major problems encountered in their analysis were lack of resolution both in host and parasite phylogenies. However, comparisons of the phylogenies of hosts and parasites were generally consistent with an hypothesis of co-speciation in part because all the host species are macropodids with an oesophagus lined with prominent papillae (Obendorf 1984). *Macropus dorsalis* (Gray, 1837) parasitised by *C. leptos* (Mawson, 1965), *M. eugenii* (Desmarest, 1817) parasitised by *C. kartana* (Mawson, 1955), *M. parma* Waterhouse, 1845 parasitised by *C. parma* (Johnston and Mawson, 1939), *M. parryi* Bennett, 1835 parasitised by *C. elegans* Beveridge, 1982 and *M. rufogriseus* (Desmarest, 1817) parasitised by *C. alatus* Beveridge, 1982 and *C. perplexus* Beveridge, 1982

belong to a single subgenus, *Notamacropus*, while *C. wallabiae* occurs in the related genus *Wallabia*. Two potential examples of colonization rather than host speciation were noted (Beveridge & Chilton 2001), one of which was the purported occurrence of *C. wallabiae* in both *W. bicolor* and *M. irma*. The description of the new species in *M. irma* thus potentially excludes one of these examples of colonisation and further supports the hypothesis of co-speciation between hosts and parasites in the genus.

Beveridge & Chilton (2001) argued that the cloacinine nematodes of macropodid marsupials may represent excellent models for the study of the way in which mechanisms such as co-speciation and colonization interplay in the evolution of parasitic nematodes, with their study suggesting that colonization is the more significant mechanism. However, critical for such studies is a sound taxonomic basis. The description of the two nematodes presented in this paper provides support on the one hand for the colonization hypothesis advanced for species of the *R. australis* complex and on the other hand for the co-speciation hypothesis advanced in the case of the genus *Cyclostrongylus* (see Beveridge & Chilton 2001).

Acknowledgements

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